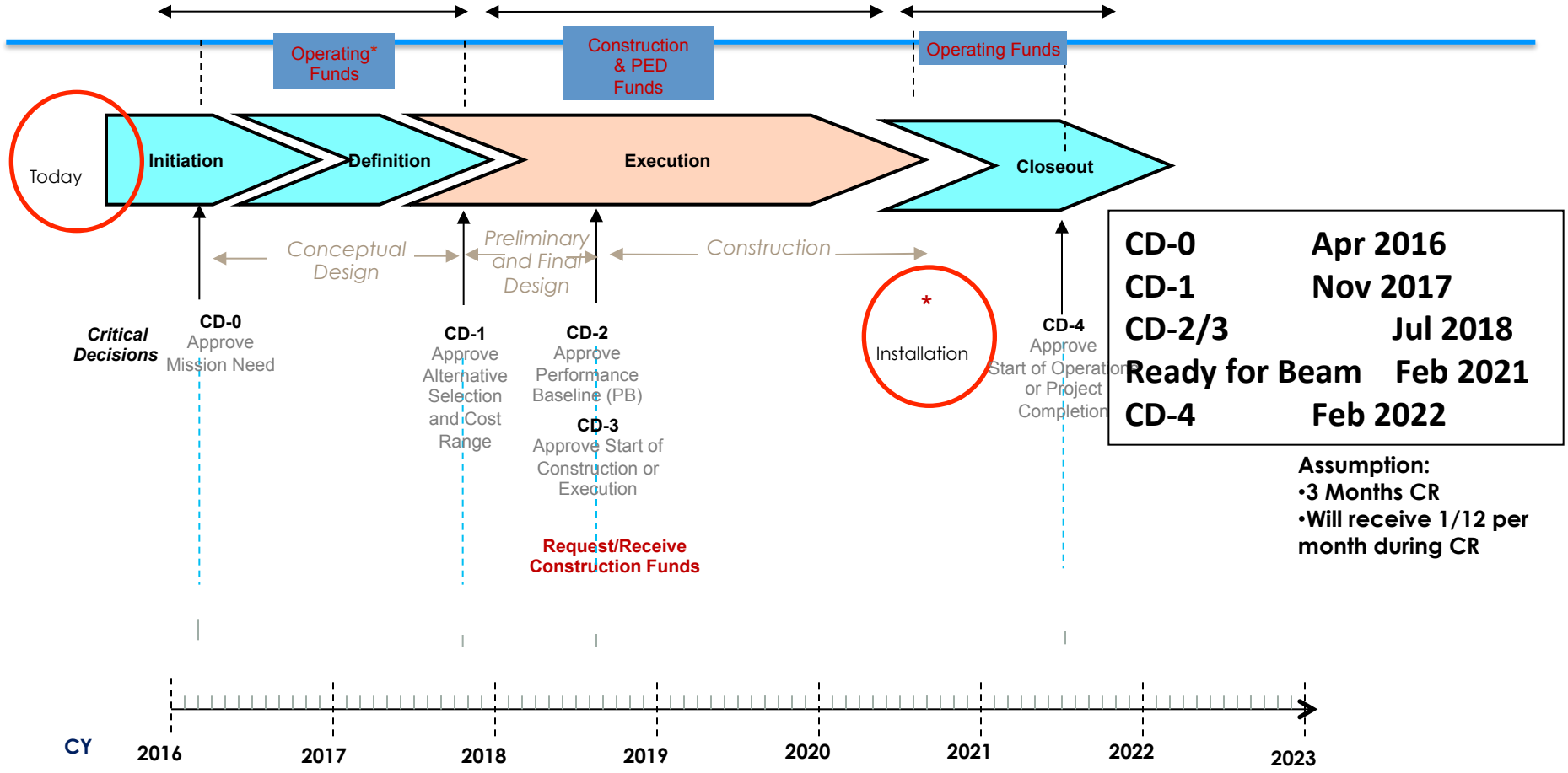
Calorimeter Overview

John Haggerty

Scope of this breakout session

- EMCAL
- HCAL
  - Inner HCAL inside the solenoid
  - Outer HCAL
- Calorimeter electronics
  - SiPM's
  - On-detector electronics
  - Near-detector electronics (digitizers)

Critical Decision Scenario



CD-0	Apr 2016
CD-1	Nov 2017
CD-2/3	Jul 2018
Ready for Beam	Feb 2021
CD-4	Feb 2022

Assumption:
- 3 Months CR
- Will receive 1/12 per month during CR

- Operating Funds are used for conceptual design between CD-0 and CD-1. Operating funds may also be used prior to CD-4 for R&D, NEPA, D&D, ES&H, transition, startup, and training costs. Non-federal funds from other sources that are considered capital funds and are included in the "Total line item cost" as OPC.
- Good Practice—For the first year that TEC is requested, ensure that OPC is also requested for that year. The OPC will allow the project to continue in a long CR until TEC is available and new starts are allowed.
- MIE funds are more flexible than Line Items. Moving OPC to TEC or vice versa is much easier than for Line-Item reprogramming since MIE funds are "batched."
- New Start is defined as the first use/appropriation of any TEC funds (including TEC PED) for both line items and MIEs project.

Assumptions

- Critical Decisions
  - CD-0 April 2016
  - CD-1 November 2017
  - CD-2/3 July 2018
  - BES II 2019-2020 (IR inaccessible)
  - Ready for beam Feb 2021
- BNL funded R&D will support the effort until CD-2/3
  - We are using Program Development and LDRD funding in addition to PHENIX R&D
- Each of these projects has about 100 costed tasks in a Project file
  - The off-project R&D effort is tracked as WBS items 2.{4,5,6}
- We have put in place the mechanism for a risk-based contingency calculation, but for now have contingencies in the 25-40% range

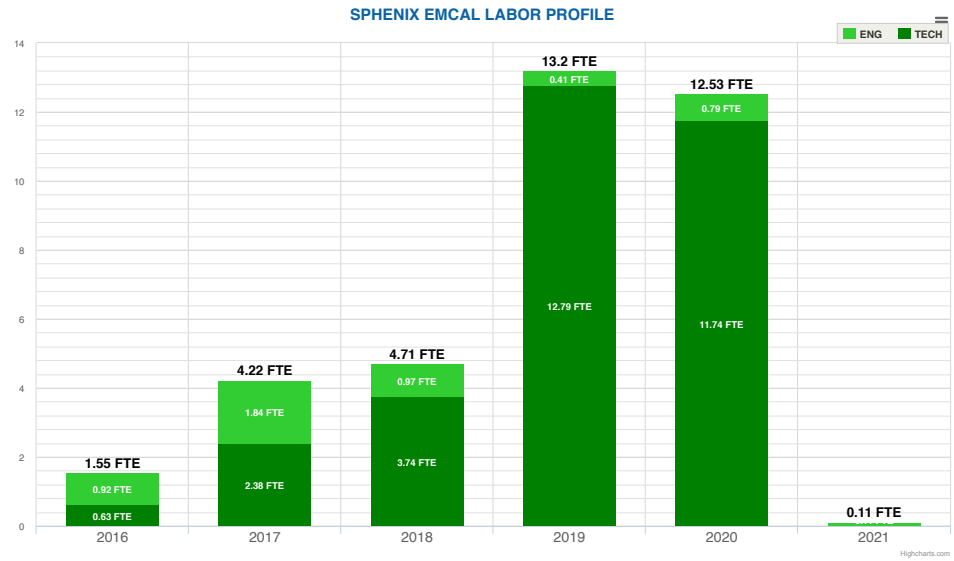
Calorimeter collaboration

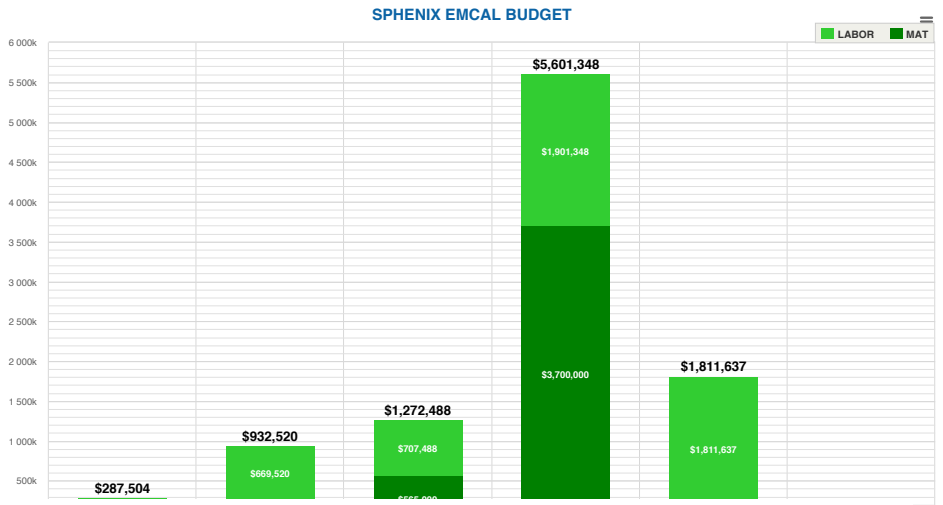
- EMCAL
  - UCLA
  - UIUC
  - University of Michigan
  - BNL
- HCAL
  - Iowa State
  - Georgia State (
  - University of Colorado
  - BNL
  - Calorimeter electronics
  - Columbia University
  - BNL
- Several institutions in the new collaboration (Wayne State, Lehigh, UTFSM) have expressed interest in calorimetry

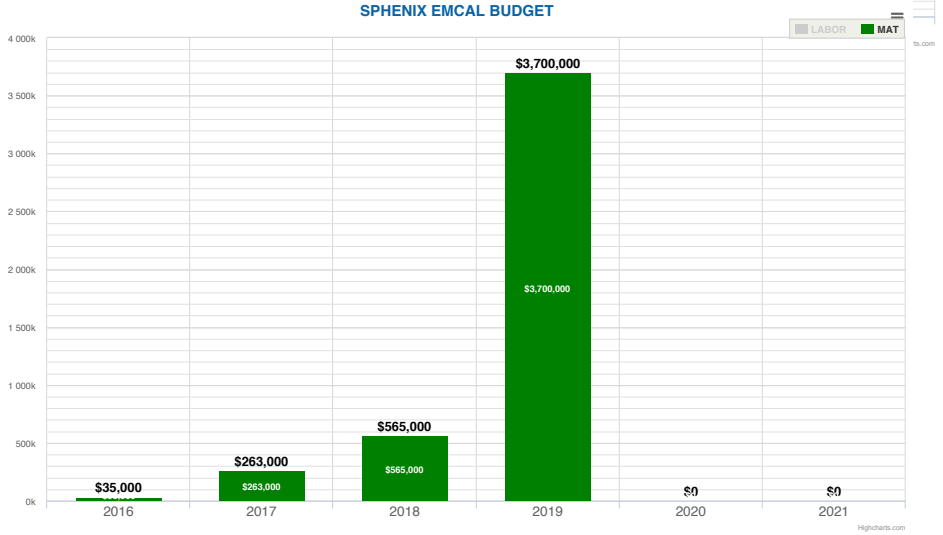
Summary of sPHENIX Cost Estimate at WBS Level 2

WBS	WBS Description	k$'s Labor	k$'s Material	k$'s Total
1.1	Project Management	5312	95	5407
1.2	Magnet	3975	1906	5880
1.4	EMCaL	5362	4563	9925
1.5	HCaL	5384	6159	11543
1.6	Calorimeter Electronics	1504	4404	5908
1.7	DAQ & Trigger	855	1728	2583
1.8	Infrastructure	1927	1668	3595
1.9	Installation/Integration	1973	312	2284
Subtotal sPHENIX TPC FIX FY 16 k$		**26292**	**20834**	**47126**
Indirect Estimates		8992	1945	10937
Escalation Estimate		2643	1021	3664
Subtotal sPHENIX TPC FY fully Loaded AY k$		**37927**	**23800**	**61727**
Contingency Estimate		5987	6955	12942
Total sPHENIX TPC (k$)		**43914**	**30755**	**74669**

EMCAL Budget and Labor

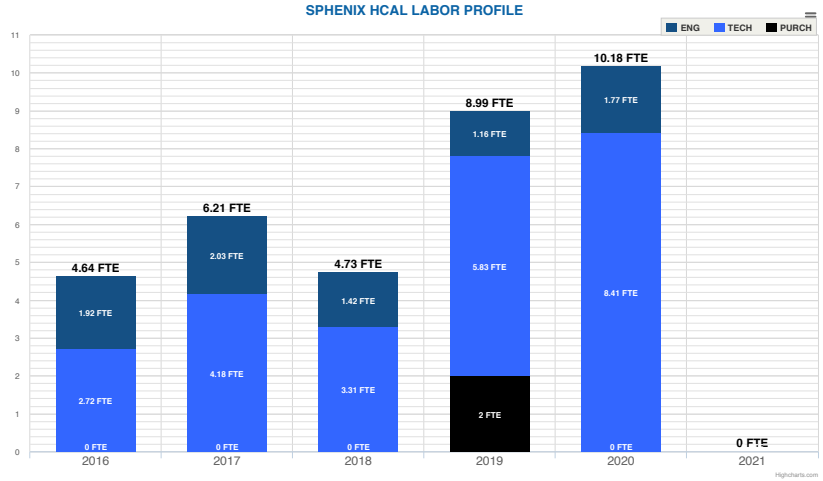


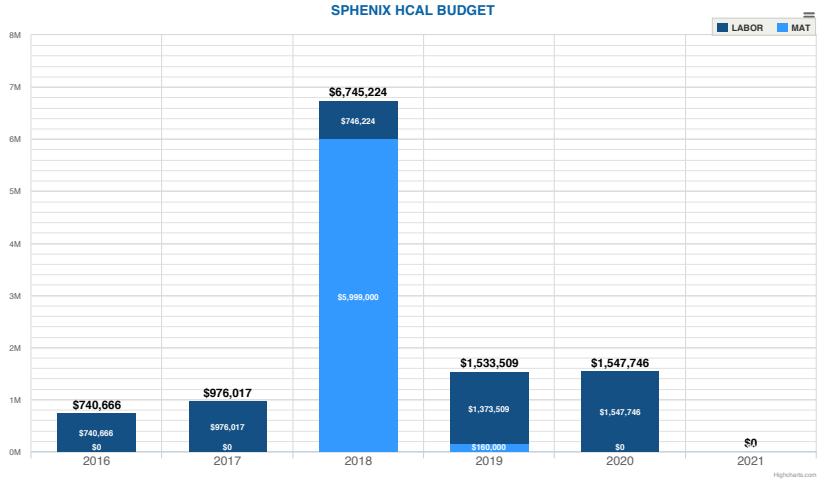


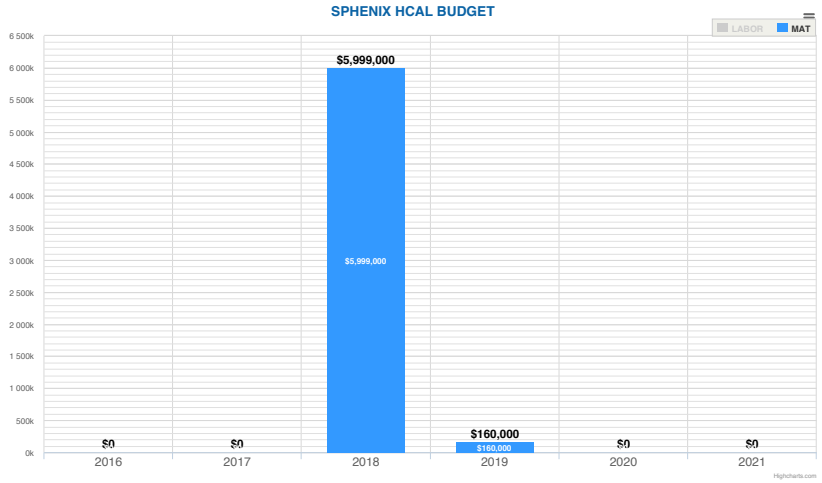


FY16$ direct costs

HCAL Budget and Labor

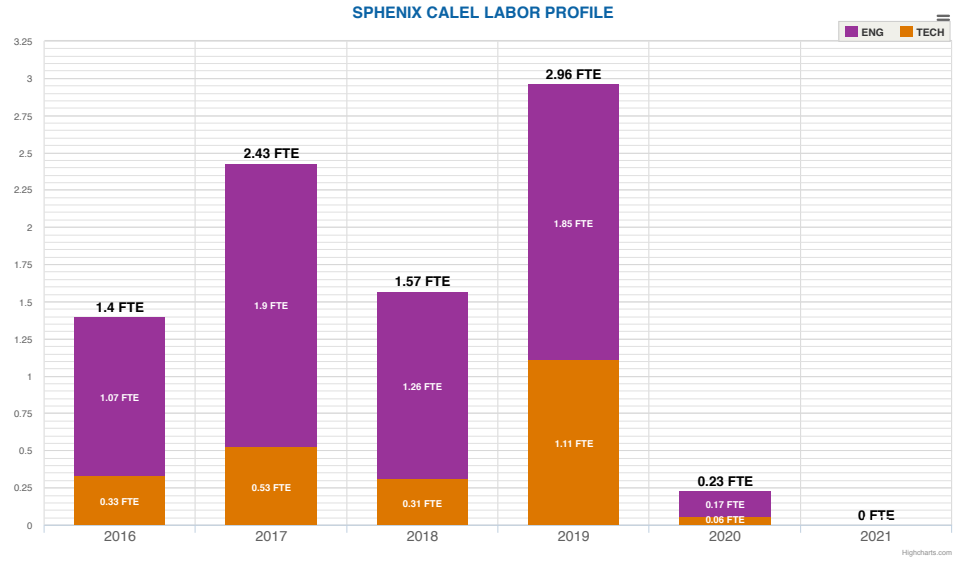


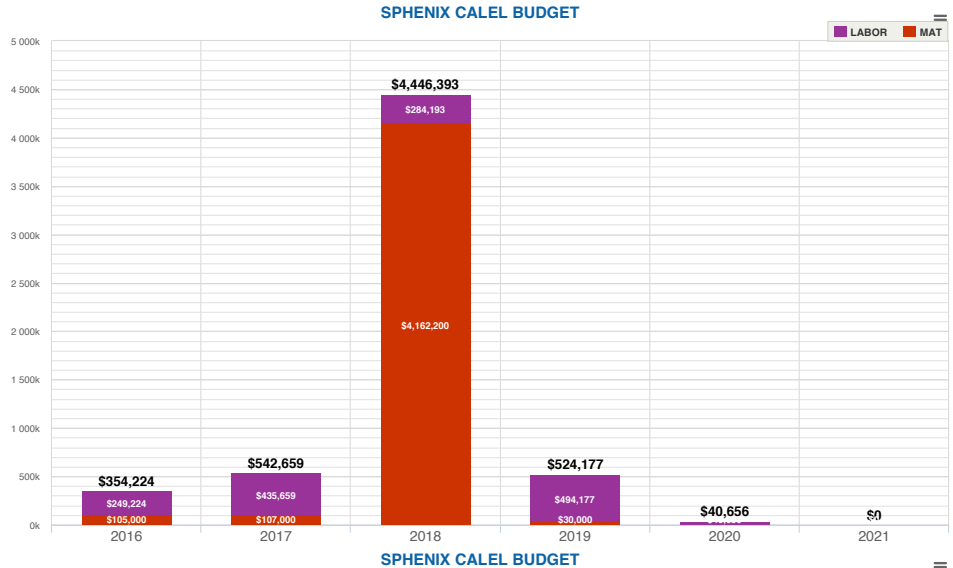


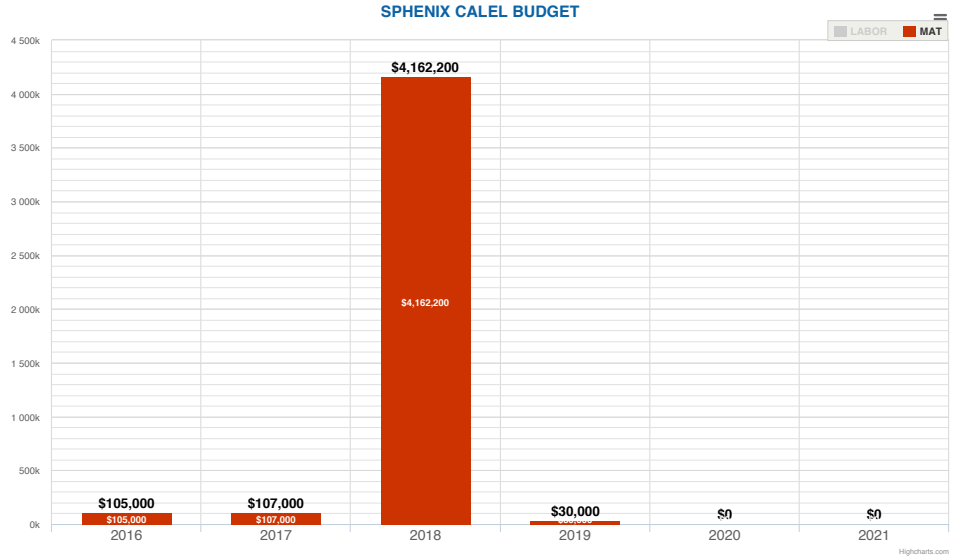


FY16$ direct costs

Cal Electronics Budget and Labor







FY16$ direct costs

Basis of Estimate example

- We prepared BOE documents for the cost drivers and smaller components (available on web site)
- We have contacted vendors in some cases so we can base costs on budgetary quotes
- Designs and drawing are maturing, we need more legwork to value engineer and work with vendors
- R&D contracts are in place for some critical components (THP, Uniplast)
- The cost drivers
  - EMCAL
    - Tungsten powder/calorimeter towers
    - SiPM's
  - HCAL
    - Absorber steel
    - Scintillator

	sPHENIX Detector **Relativistic Heavy Ion Collider** **BASIS of ESTIMATE (BoE)**	**Date of Est:** October 2015 **Prepared by:** Lajoie/Haggerty/Kistenev **DocNo. (refer Rev. Log):**

WBS number: 1.5.3.3.1.4	**WBS Title:** Procure absorber (Outer HCAL)

WBS Dictionary Definition: See WBS dictionary.

Estimate Type (check all that apply):

___ Work Complete
___ Existing Purchase Order
___ Catalog Listing or Industrial Construction Database
___ Documented Vendor Quotation based on Drawings/ Sketches/ Specifications
___ Budgetary Estimate by Vendor/Fabricator based on Sketches, Drawings, or other Written Correspondence
___ Engineering Estimate based on Similar Items or Procedures
_x_ Engineering Estimate based on Analysis
___ Expert Opinion

Supporting Documents

See drawing of outer HCAL absorber.

Details of the Base Estimate (explanation of the Work)

The absorber plates are tapered 1006 magnet steel. Based on informal conversations and budgetary Estimates from a number of steel foundries (Atlas in Indiana and Strecks in New York) we estimate that the cost of machined steel is about $5/lb and there are few mechanical complexities in the absorber plates. An effort has been made to minimize drilled and tapped holes. The cost of 1006 steel is not expected to be significantly different compared to ordinary machined C1020/1040 steel. For the present design, the Outer HCAL is about 854,000 lbs. and the unit price is estimated at $4.48/lb.

Assumptions Used in Developing Estimate:

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Cost Summary

	Material [$]	Designer [d]	Engineer [d]	Tech [d]	Physicist [d]	Student [d]
Subsystem:	3,830,000	x	x	x	x	x

Calorimetry issues and concerns

- Construct v2 calorimeter prototypes and test them in beam [Kistenev, Stoll]
- Continue SiPM rad-damage studies and finalize our scheme for minimizing the effects [Stoll]
- Complete design and test calibration scheme [Kistenev]
- Continue and expand simulation efforts [Huang]
  - Explore modest design variations in calorimeters
    - e/h separation, e/h response, projectivity
  - Next round of GEANT studies of jets in heavy ions
- Test the next generation digitizer (bench and beam) [Chi]
- Develop calorimeter trigger algorithm [Huang, Mannel]
- Refine cost estimates (quotes, vendor visits)
- Revise project plan based on experience of pre-production and beam tests

This session

:00 - 17:00 Calorimeter Break Out

Location: 2-160

14:00 **Calorimeter Overview** *20'*
Speaker: John Haggerty (Brookhaven National Laboratory)

14:20 **Calorimeter Simulations** *20'*
Speaker: Dr. Jin Huang (Brookhaven National Lab)
Material: Slides

14:40 **EMCal R&D and Prototype Plans** *20'*
Speaker: Mr. Sean Stoll (BNL Physics)
Material: Slides

15:00 **HCal R&D and Prototype Plans** *20'*
Speaker: Edward Kistenev

15:20 **EMCal Production and Assembly** *20'*
Speaker: Christian Cullen (BNL)
Material: Slides

15:40 **HCal Production and Assembly** *20'*
Speaker: Anatoli Gordeev (BNL/PHYSICS)
Material: Slides

16:00 **Cal Electronics R&D and Prototype Plans** *20'*
Speaker: Eric Mannel (Brookhaven National Laboratory)
Material: Slides

16:20 **Cal Electronics Digitizer Production** *20'*
Speaker: Cheng-Yi Chi (Columbia University)
Material: Slides

16:40 **Cal Electronics On-Detector** *20'*
Speaker: Mr. Steve Boose (BNL/PHENIX)
Material: Slides

Simulations

EMCAL and HCAL R&D

EMCAL and HCAL mechanics

Electronics